# The James Webb Space Telescope: Contamination Control and Materials


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## Abstract

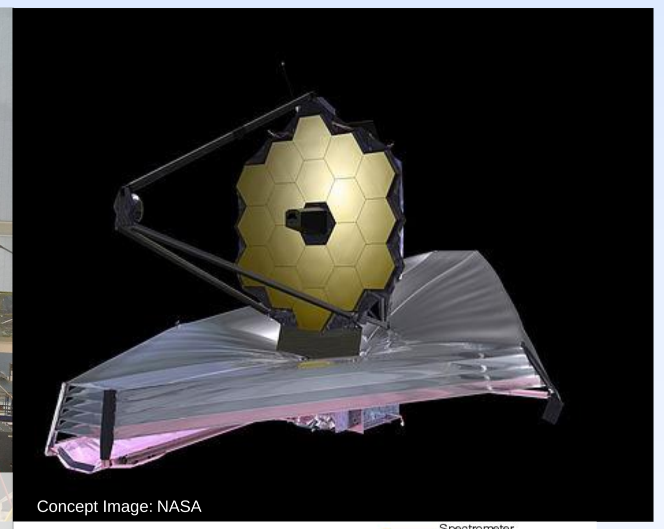
The James Webb Space Telescope (JWST), expected to launch in 2018 or early 2019, will be the premier observatory for astronomers worldwide. It is optimized for infrared wavelengths and observation from up to 1 million miles from Earth. JWST includes an Integrated Science Instrument Module (ISIM) contains the four main instruments used to observe deep space: Near-Infrared Camera (NIRCam), Near-Infrared Spectrograph (NIRSpec), Mid-Infrared Instrument (MIRI), and Fine Guidance Sensor/Near InfraRed Imager and Slitless Spectrograph (FGS/NIRISS).

JWST is extremely sensitive to contamination directly resulting in degradation to performance of the telescope. Contamination control has been an essential focus of this mission since the beginning of this observatory. A particular challenge has been contamination challenges in vacuum chamber operations. [7]

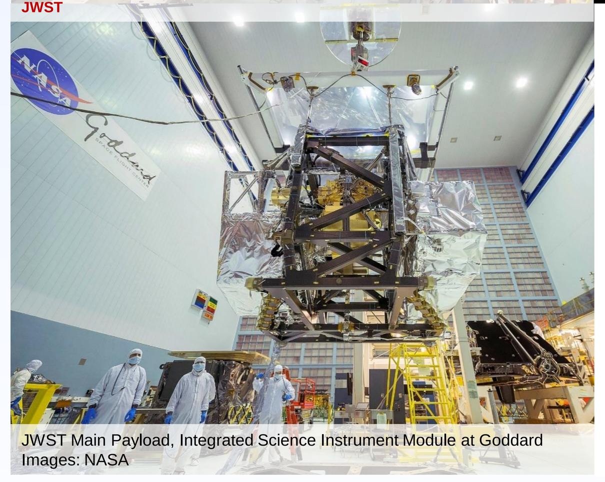

## Mission Objectives

First Light & Reionization, Assembly of Galaxies, Birth of Stars & Protoplanetary Systems, Planets and Origins of life [1]

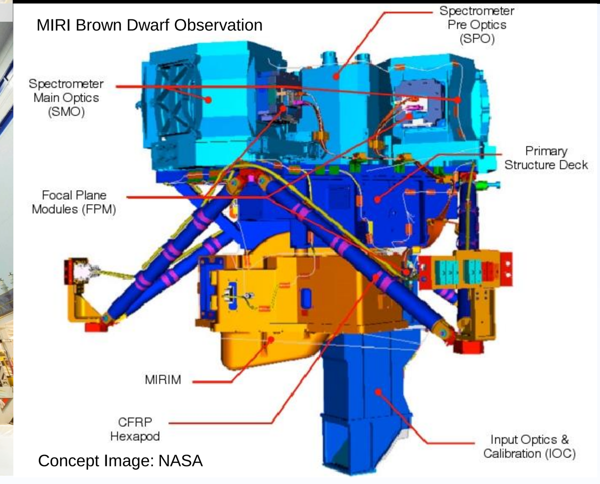
Goddard Space Flight Center High Bay Clean Room
E. Stewart, Presenter, is a Contamination and Coatings Engineering Intern for JWST



Concept Image: NASA



JWST Main Payload, Integrated Science Instrument Module at Goddard
Images: NASA




MIRI Brown Dwarf Observation
Concept Image: NASA

## Contamination Control Methods

One of the most important areas of concern for contamination is the state of the primary mirrors. These mirrors are directly used to capture the light of stars, exoplanets and galaxies as shown in Figure 1. Molecular and particulate contamination on the surface of the mirrors can result in degradation of their performance and the images we will receive looking at these objects. Table 2 shows molecular contamination requirements for the mirrors.[7] To ensure these requirements are met, methods such as Image Analysis (IA) are used on wafers for particle counting and sizing. [2]

Throughout the life span of integration of JWST, cryo-vacuum tests were monitored and controlled in order to minimize molecular contamination during warm up back to ambient temperatures. Thermal vacuum tests contribute significantly to the overall molecular contamination. To ensure minimal outgassing and desired contamination control, material selection for all aspects of the telescope has needed to be considered. [7] JWST is currently undergoing a 3 month long test to validate the sensors and mirror alignments in the temperatures of deep space. A schematic of Johnson's Chamber A is shown in Figure 2 with the placement of the CQCMs. With the use of both a nitrogen and helium shroud, the telescope is subjected to colder than 50 K conditions. [6] Thermal monitoring of outgassing during cryo-chamber tests is monitored by cryogenic quartz crystal microbalances (CQCM), shown in Figure 2. [4] Figure 3 show the use of Molecular Adsorber Coating (MAC). MAC can be used in chamber environments to reduce outgassing rates, reduce the pump down process, and achieve high vacuum and lower pressures. MAC was specifically used in this purpose to trap silicone based contaminants and prevent harmful outgassed species to deposit on sensitive JWST surfaces. [3]

| | Particulate PAC- Percent Area Coverage | Molecular (Angstroms) | Water Ice (Angstroms) |
|---|---|---|---|
| Primary Mirror (PM) | 1.5 | 350 | 42 |
| Secondary Mirror Assembly (SMA) | 0.5 | 350 | 42 |
| Tertiary Mirror Assembly (TMA) | 0.5 | 350 | 42 |
| Fine Steering Mirror (FSM) | 0.5 | 325 | 5 |

Table 2: Optical Telescope Element Contamination Allocations [7]

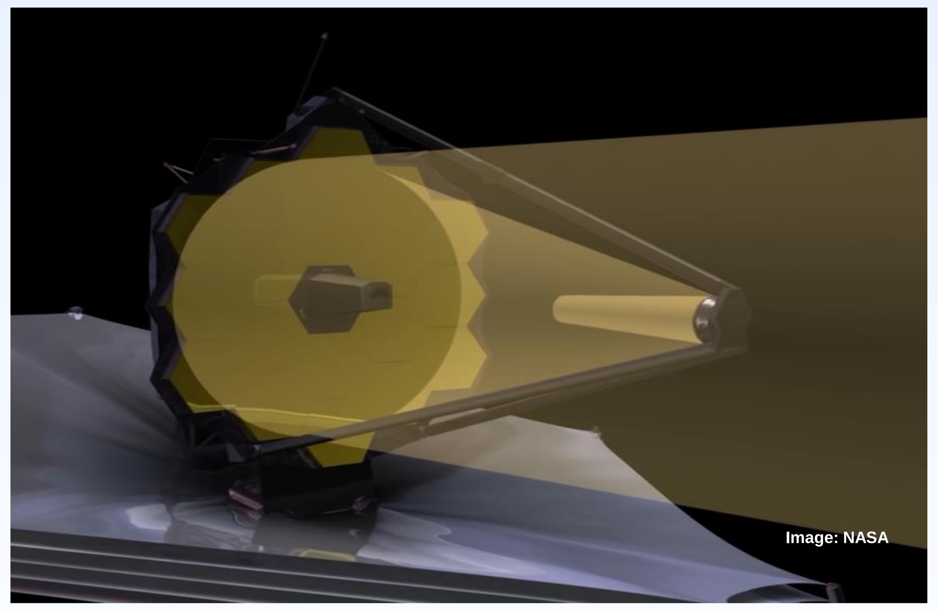
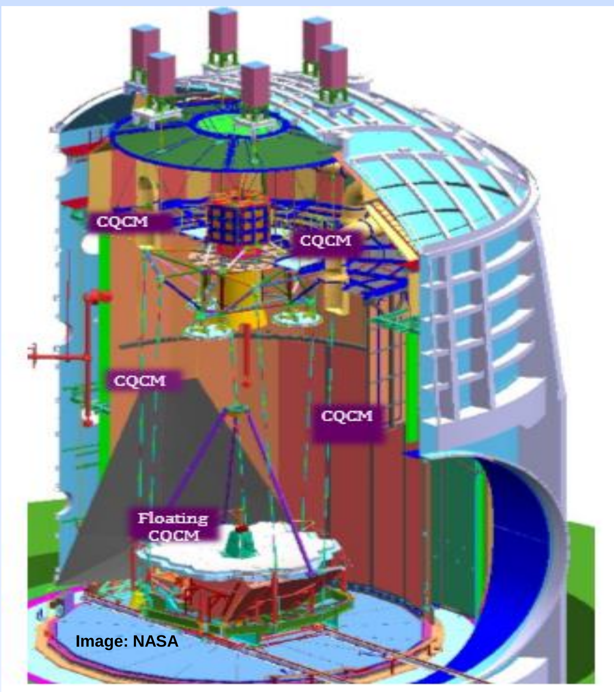



Figure 1: Light Path with Optical Telescope Element [8]



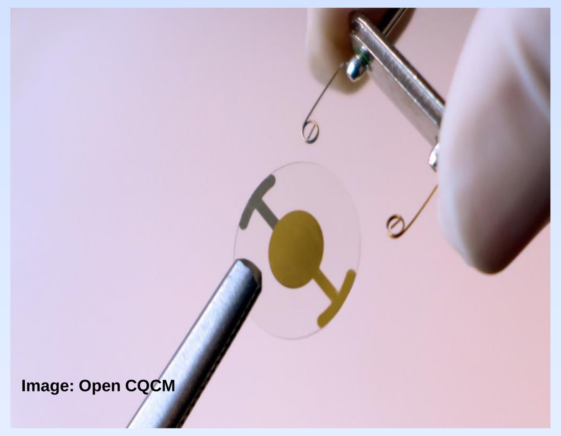




Figure 2: Johnson Space Center Chamber A Schematic and CQCM placement [4,5]

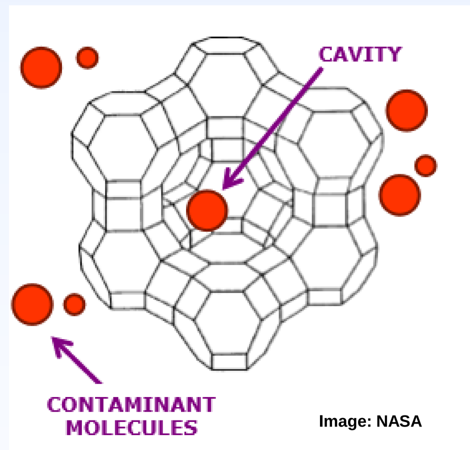




Figure 3: Molecular Adsorber Coating [3]

## Motivation

JWST is the next premier observatory and the successor to the Hubble Telescope. It is an international collaboration between NASA, ESA, and CSA. This mission has led to monumental advances in technology. Some of these state of the art technologies are: 18 separate segmented gold coated lightweight beryllium mirrors, tennis court sized sunshield, and infrared detectors. [3]

For JWST, cleanliness is imperative to achieve thermal and optical mission performance requirements. Contamination requirements have been set in place and monitored for all aspects of the telescope during Integration and Testing (I&T). JWST I&T has taken place in clean rooms at Goddard and Johnson Space Centers.
Table 1 below lists molecular contaminants of concern and the source of these contaminants. [7]

| *Molecular Contaminants* | *Source of Contaminants* |
|---|---|
| Hydrocarbons | Plastics |
| Pthalates | Adhesives |
| Palmitates | Lubricants |
| Esters | Expoxies |
| Silicones | Potting Compounds |

Table 1: Optical Telescope Element Contamination Allocations [3]


## References

*NASA*, NASA, jwst.nasa.gov/science.html. For mission objectives 1
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120015308.pdf 2
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160010636.pdf 3
http://opengcm.com/wp-content/uploads/2015/01/Quartz-Crystal-Microbalance-openQCM-sensor-1024x576.png 4
http://www.stsci.edu/jwst/overview/design/testing 5
https://spaceflightnow.com/2017/05/09/james-webb-space-telescope-shipped-to-texas-for-its-biggest-test-yet/ 6
file:///C:/Users/elaines/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/91960K.pdf 7
https://www.youtube.com/watch?v=y9Z2GbFJWmo 8



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## Conclusion: Path to Launch

In the path forward, contamination will be monitored up until launch.. Through the methods discussed in the poster, molecular and particulate contamination will be mitigated to ensure mission success.